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ABSTRACT

Research on Vygotsky's zone of proximal development theory was used as a foundation to investigate differences in the learning and transfer ability of 30 students with learning disabilities (LD) and 30 students with matched low achievement (LA), from grades 7 and 8. The two groups were assessed on their problem-solving ability on a balance scale learning task and three transfer tasks under unassisted and assisted conditions. Analyses were conducted to determine group differences in performance on several measures of learning, transfer, and maintenance. Results indicated inconsistent performance differences between the two groups. Students with LD performed similarly to students with LA on measures associated with the learning task, but generally outperformed students with LA on measures associated with the transfer task. It is concluded that students with LD are more capable than students with LA of maintaining and transferring their learning, suggesting that the ability to transfer learning is more closely related to general intelligence than to a specific learning disability. (30 references) (JDD)

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Differences in Transfer Propensity and Learning Speed on Balance-Scale Problems

for Students with Learning Disabilities and other Low-Achieving Students

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Running Head: DIFFERENCES IN LEARNING AND TRANSFER

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Abstract

In this study, research on Vygotsky's zone of proximal development theory was used as a foundation to investigate differences in the learning and transfer ability of 30 students with learning disabilities (LD) and 30 students with matched low achievement (LA). The two groups were assessed on one learning task and three transfer tasks under unassisted and assisted conditions (i.e., dynamic assessment). A 2 group by 4 session (i.e., pretest, training, maintenance/transfer, and delayed maintenance) mixed, factorial design was employed for data collection. Seven separate analyses and several post-hoc analyses were conducted to determine group differences in performance on several measures of learning, transfer, and maintenance. Results of the analyses indicated inconsistent performance differences between the two groups. Students with LD performed similarly to students with LA on measures associated with the learning task, but generally outperformed students with LA on measures associated with the transfer task. The results of this study are discussed in light of previous research using dynamic assessment to describe the learning and transfer abilities of various populations. Further, discussion of the results also focused on research investigating the problem-solving abilities of students with LD.

Few issues in the special education field have been as feverishly debated as the definition of learning disabilities (LD) as a handicapping condition (Hammill, 1990). Lack of definitional consensus has subsequently resulted in inconsistent identification practices (Adelman & Taylor, 1986; Keogh, 1988) and the misidentification of many nondisabled students, particularly low-achieving students as learning disabled (Ysseldyke et al., 1983). Further, precise definitions in any field of study provide the foundations for generating and testing theories, classifying phenomena, and communicating with other professionals (Hammill, 1990). Without agreement on the definition of a learning disability or the manner in which learning disabilities are manifest, developing measures which can assess the presence and severity of the disability and the development of remedial interventions is difficult.

Although inconsistencies in definitional practices are the result of a multitude of factors, poor conceptualization of the LD phenomena is one of the most important contributors to this confusion (Keogh, 1988; Swanson, 1988). Hence, the development of a validated conceptual framework for understanding learning disabilities is proposed as a viable solution for improving definition practices. A conceptual framework provides the foundation for integrating results from series of studies for the purpose of arriving at a more well-defined construct of learning disabilities (Swanson, 1988) and subsequent resolution of definitional issues.

Current theories of cognitive psychology provide a viable framework for developing a program of research aimed at uncovering the psychological processing deficiencies underlying learning disabilities (Kolligan & Sternberg, 1987;

Swanson, 1987, 1988). The last three decades of cognitive research have been successful in identifying cognitive processes which differentiate effective and ineffective learners (Brown, Bransford, Ferrara, & Campione, 1982; Butterfield & Ferretti, 1987). Many of the findings regarding ineffective learners have been paralleled in studies of students with LD (Brown & Campione, 1986; Stanovich, 1986).

Within the framework of cognitive theory, investigations of problem-solving behavior hold potential for furthering our conceptual understanding of learning disabilities. That is, students with LD may exhibit developmental delays in their problem-solving abilities (Meltzer, Solomon, Fenton, & Levine, 1989; Stone & Michals, 1986). Results of this research, however, is potentially confounded by failure to control for the students' ability (e.g., Meltzer, Solomon, Fenton, & Levine, 1989; Stone & Forman, 1988). Thus, further investigations of specific cognitive processes underlying problem-solving performance in LD populations that control for ability are clearly warranted.

Critically important to effective problem solving is the ability to access acquired knowledge and transfer that knowledge to novel problems. Limited research exists, however, examining the transfer abilities of students with LD despite a general consensus among professionals that students with LD exhibit difficulties transferring knowledge and skills (Alley, Deshler, Clark, Schumaker, & Warner, 1983; Telzrow & Speer, 1986). One plausible framework for investigating the problem solving abilities of students with LD is based on Vygotsky's theory (1978) of the "zone of proximal development" and subsequent investigations of learning speed and transfer (Campione, Brown, Ferrara, Jones, &

Steinberg, 1985; Day & Hall, 1988). Vygotsky theorized that children's problem-solving ability is more precisely assessed by determining students' actual level of development along with their potential to profit from instruction (i.e., the zone of proximal development). Dynamic testing methods (i.e., provision of increasingly explicit prompts to aid problem solution) along with static measures (i.e., no assistance is provided to aid problem solution) were used in Vygotskian-based research to determine differences in the zone of proximal development for students of varying ability levels. The value of this research for future investigations of students with LD is the strength of its experimental methods to delineate inter- and intra-group differences in learning and transfer ability on problem-solving tasks.

The purpose of this study was to compare the performance of students with LD to students with LA on a balance scale task (Siegler, 1976) and 3 related transfer tasks. Dynamic assessment techniques were used to measure the two groups' ability to learn a problem-solving strategy and to transfer and maintain their learning. Students with LD and students with LA were selected in this study because previous research has been unsuccessful in discriminating the two populations on various academic and ability measures (Ysseldyke et al., 1983).

Method

Subjects

Thirty students with learning disabilities and 30 students with matched low achievement (n=60) were randomly selected from the seventh and eighth grades in two school districts. Students with LD were selected according to the following criteria: (a) a significant discrepancy between assessed aptitude and achievement corresponding to an alpha level of .04 (or 1.75 standard deviations) in reading and/or math, and (b) a Full-Scale score of 100 or higher on the Wechsler Intelligence Scale for Children-Revised (WISC-R) (Wechsler, 1974). In addition, equal proportions of students with disabilities in reading, math, or reading and math were chosen to control for differences in task performance that may arise due to specific area of disability and to increase the generalizability of re ılts.

The full regression estimated true score formula was used to determine the discrepancy between achievement and ability (Reynolds, 1984-1985). Math and/or reading cluster achievement scores from the Woodcock-Johnson Psychoeducational Battery (WJ) (Woodcock-Johnson, 1977) and Full-Scale scores of the WISC-R were used in the regression formula. The Full-Scale WISC-R score was not used if a 15 point discrepancy existed between the student's WISC-R Performance and Verbal score. In such cases, the higher of the two scores was used as the measure of aptitude.

Selection according to the aforementioned criteria, however, resulted in insufficient numbers of students in each of the disability subgroups. Thus, three adaptations to the selection criteria were made. First, if a student did not have a Full-Scale WISC-R score of 100 or higher, they were selected based on Performance or Verbal scores above 100. Five students with LD fell into this category. Second, the WISC-R Full-Scale score derived after considering the Freedom from Distractibility factor (Sattler, 1982) was used in determining the discrepancy. One student with a learning disability fell into this category. Third, a 24 point standard score discrepancy between aptitude and achievement was employed if the first two criteria did no result in a sufficient sample. Five students with LD fell into this category.

Low-achieving students were selected according to the following criteria: (a) achievement levels that matched the students with LD on group-administered achievement tests, (b) math and/or reading scores at or below the 33rd percentile on group-administered achievement tests (c) no significant discrepancy between assessed aptitude and achievement corresponding to an alpha level of .04 in reading and/or math, and (d) scores below the 50th percentile on group-administered ability tests. Achievement and aptitude were assessed by group-administered standardized tests. For district one, composite percentile scores in math and/or reading along with percentile scores from three ability subtests on the Iowa Test of Basic Skills (ITBS) (Lindquist & Hieronymus, 1976) were used to assess the discrepancy between achievement and aptitude. For school district 2, composite percentile scores for reading and/or math along with percentile scores on the Education Ability Subtest on the Science Research Associates Test of Basic Skills (SRA) (Science Research Associates Committee on the SRA test, 1987) were used to assess the discrepancy between achievement and aptitude.

The formula used in calculating the aptitude-achievement discrepancy for the students with LD was employed to determine if an aptitude-achievement discrepancy existed for students with LA. For students in school district one, discrepancy between achievement and aptitude was determined for all three ability subtests.

Exceptions were made in the sampling process primarily because of difficulties encountered when matching students on both reading and math scores Of the ten students with reading and math disabilities, five were matched to students with LA within a 6% range on math and reading scores. For the remaining five students with math and reading disabilities, closer matches on achievement were unable to be obtained. In this regard, students with LA whose percentile scores most closely approximated both the math and reading percentile scores were chosen. Exact matches were also difficult to obtain for six of the students with reading or math disabilities. Five of the six students were matched to students with LA within a 5% range on math or reading scores. The remaining student with a math disability was matched to a student with LA within a 9% range on their math scores.

Descriptive data on the students with LD and students with LA, both demographic and academic, were gathered from the school records. Academic data included aptitude and achievement test scores from both individually- and group-administered tests. Demographic data collected from both districts included indices of race, grade, age, sex, and social economic status. Tables 1 and 2 are presented as summaries of this data.

Insert Tables 1 and 2

Design and Dependent Measures

A 2 group by 4 session factorial repeated measures design was employed for data collection over the pretest, training, maintenance/transfer, and delayed maintenance sessions. Data was collected on one learning task and three transfer tasks during two different assessment conditions (i.e., unassisted and assisted) . In the unassisted condition, number of problems correctly solved was the dependent measure and was used as an indicator of initial level of rule knowledge, spontaneous transfer, and maintenance in the unassisted condition. Whereas, in the assisted condition, sum of the weighted prompts needed by the student to reach mastery was the dependent measure. Each prompt was weighted in relation to the degree of explicit explanation it provided for the student in terms problem solution. These prompts had been analyzed and weighted in a previous study (see Day & Hall, 1988) and were used in this study as an indicator of learning speed, transfer propensity, and maintenance in the assisted condition for the learning and transfer tasks.

Interrater reliability. Data on the reliability of scoring procedures employed in the unassisted and assisted conditions were collected for 31 percent of the sessions throughout the duration of the study. To determine interrater reliability, one of the experimenters independently scored the students' performance using the same form as the experimenter conducting the testing. Interrater reliability was determined by dividing the number of agreements by the number of agreements plus disagreements (Bakeman & Gottman, 1986). Interrater reliability for the unassisted and assisted conditions were .98 and .99, respectively.

Apparatus (Balance Scales)

For the learning task, a 4-peg balance scale (Siegler, 1976) was constructed and used to assess differences in initial level of rule knowledge, learning speed, and maintenance unassisted and assisted for the groups. This scale had pegs on either side of the fulcrum that were numbered from one to four beginning with the peg closest to the fulcrum. Metal weights of equal units were placed in varying numbers on each of the pegs. An addition strategy was used to compute torque for each problem. That is, if two weights were placed on the fourth peg on one side of the fulcrum, the student would add the number four twice. The number derived for both sides of the scale were then compared by the student to solve the problem.

Three separate transfer tasks were used to assess differences in spontaneous transfer, transfer propensity, and maintenance unassisted and maintenance assisted for the two groups. For the near transfer task, a 10-peg balance scale was constructed. This scale was similar in construction and manipulated in the same fashion as the 4-peg balance scale.

For the far transfer task, two small metal baskets were hung from either arm of the 10-peg balance scale. Weights of equal units were placed in varying amounts in each of the baskets. The baskets' weight equalled two of the metal weights. In order to solve problems for the far transfer task, students were required to account for the weight of the baskets in their calculations of torque.

For the very far transfer task, a doll-sized teeter-totter with a moveable fulcrum was constructed. The teeter-totter could be moved to five different positions over the fulcrum. These positions were numbered from 1 to 3 with the number 1 representing the center of the teeter-totter. Six dolls (two small, two medium, and two large) were also constructed that were placed at either end of the teeter-totter. The dolls' weight varied in a two to one ratio with the largest dolls being four times as heavy as the smallest dolls. To solve torque problems using the teeter-totter required a qualitatively different strategy from the previous learning and transfer tasks. That is, the student counted the weight of the doll nearest to the fulcrum once and multiplied the weight of the doll furthest from the fulcrum by the number over the fulcrum.

Procedures

Procedures from the Day and Hall (1988) study were used because of their power in specifying group and individual differences. Asse ;sment of the learning and transfer tasks was conducted with individual students over four sessions. For each task, students were assessed under unassisted and assisted conditions, respectively. In the unassisted condition, students were asked to solve various balance scale problems without receiving feedback regarding the appropriateness of solution strategies used. Feedback was given only in the instance of error due to miscalculation. That is, in the event of an error, students were asked to show their work on paper. If the error was due to a miscalculation, students were asked to recheck their work. In the assisted condition, students were given feedback to aid problem solution in the form of increasingly explicit verbal prompts (see e.g., Day & Hall, 1988). For example, for the 4-peg balance scale, the first prompt was "What two things make a side go down? Think about that". Whereas, for the last prompt, the student was specifically instructed in the precise strategy necessary for problem solution. For each of the learning and transfer tasks, assessment in the assisted condition immediately followed assessment in the unassisted condition.

Pretest. During this first session, students were presented with a 30 item pretest on the 4-peg balance scale to assess their initial level of rule knowledge for this task (unassisted condition). The test contained four examples each of simple weight, simple distance, and simple balance problems and six examples each of conflict weight, conflict distance, and conflict balance problems (see Siegler, 1976). For each problem, the arms of the scale were held even while students predicted which arm of the scale would fall or if the scale would balance. Because students were unable to answer 80% of the problems correctly, all students participated in the training session.

Training. Immediately following the pretest, students were presented with a series of conflict problems. When the student was unable to respond correctly to a problem or requested assistance, the experimenter provided increasingly explicit verbal prompts (assisted condition) until the student used the appropriate addition or multiplication strategy to obtain the correct response. Once the student solved three consecutive problems without assistance, the training session was terminated. The number of prompts needed to obtain each correct response was then recorded and summed across problems and used to determine learning speed.

Maintenance and transfer. This third session occurred approximately one week after the initial training session. During the first part of this session, a 15-item test was given to assess maintenance in the unassisted condition for the 4-peg balance scale. The test included items equivalent to those items on the pretest of the 4-peg balance scale. Any students unable to solve 13 of the 15 test problems were trained to mastery in the assisted condition using the same mastery criteria as employed in the training session.

During the second part of this session, students were assessed under the unassisted condition for each of the transfer tasks to determine ability to spontaneously transfer rule knowledge. For the near transfer task, the test contained three conflict distance problems, three conflict weight problems, and four conflict balance problems. The test of far transfer contained five conflict weight and conflict distance problems. Conflict balance problems were not included due to the nature of the task. The test for very far transfer was similar to the pretest in that the test for very far transfer contained each of the simple and conflict problem types (i.e., two simple weight, one simple balance, one simple distance, one conflict weight, two conflict distance, and three conflict balance). The order in which the transfer tasks were assessed was randomly determined for each student to control for order effects.

Students incapable of transferring spontaneously (i.e., they were unable to demonstrate the correct solution strategy for 8 of the 10 problems) were trained using the same procedures and mastery criteria as used during training on the 4-peg balance scale. Students were trained on the transfer tasks in the order in which spontaneous transfer had been assessed. Data collected under the assisted condition provided information about ability to access learned rule knowledge with assistance and flexibly apply it to novel tasks (transfer propensity).

Delayed Maintenance. This fourth session occurred approximately one week after the third session. During the first part of this session, students took a 15-item maintenance test on the four-peg balance scale that had problem types similar in kind and number to the maintenance test administered in the third session. The number of problems correctly solved was used as a measure of maintenance unassisted for the learning task. Because all students were able to correctly solve 13 of the 15 test problems, no further training was provided.

During the second part of this session, students were administered a ten-item maintenance test under the unassisted condition for each transfer task. These tests contained the same number and types of problems as the three tests administered to assess spontaneous transfer, and were administered in the order in which they were assessed in the third session. Further training was provided to those students who did not meet criterion as established in the third session. Data collected from this session provided information about performance on measures of maintenance unassisted and assisted for the transfer tasks.

Results

It was hypothesized that students with learning disabilities, because of higher ability, would perform significantly better on all measures of learning, maintenance, and transfer than low-achieving students. Seven separate analyses and several post hoc analyses of learning, maintenance, and transfer measures under unassisted and assisted conditions were conducted to answer research questions related to the main hypothesis. Results of these analyses rejected the main hypothesis. All significant results reported here met the .05 level. Because the procedures and analyses used in this study are complex, Figure 1 is provided as guide for the reader.

Insert Figure 1

Learning Task

For the first and second sessions, two separate one-way analyses of variance (ANOVA) were conducted to determine differences between the two groups on initial rule knowledge and learning speed. No statistically significant main effect differences were found for the two groups for initial rule knowledge (i.e., percent correct), $F(1, 58) = 2.35$, $p = .131$, or learning speed (i.e., sum of the weighted prompts), $F(1,58) = .66$, $p = .42$. Performance means and standard deviations for these two measures are listed in Tables 3 and 4.

Insert Tables 3 and 4

For the third session, Hotelling's t-test was conducted to simultaneously test for main effects in maintenance unassisted (i.e., percent correct) and maintenance assisted (i.e., sum of the weighted prompts). No statistically significant main effect differences were found, $\underline{F}(2, 57) = .185$, $\underline{p} = .83$.

For the fourth session, Hotelling's t-test was conducted to simultaneously test for main effects in maintenance unassisted and maintenance assisted for the learning and transfer tasks in the fourth session. Statistically significant main effect differences were found, $\underline{F}(6, 53) = 2.908$, $\underline{p} = .01$. Thus, post hoc univariate F-tests were conducted to determine single effects for maintenance unassisted and maintenance assisted on the learning task. No statistically significant differences were found for maintenance unassisted, $\underline{F}(1, 58) = 2.332$, $\underline{p} = .132$. Differences in maintenance assisted were not analyzed for the learning task because of insufficient variance in individual scores. Thus, results from post hoc univariate F-tests indicated that main effect differences were due to single effect differences in maintenance assisted for the transfer tasks (see next section). Means and standard deviations for maintenance unassisted and maintenance assisted in the third and fourth sessions are listed in Tables 3 and 4.

Transfer tasks

For the third session, Hotelling's t-test was used to simultaneously test for mean differences in spontaneous transfer (i.e., number correct) and transfer propensity (i.e., sum of the weighted prompts) for each of the three transfer tasks. Statistically significant main effect differences were found, $F(6, 53) = 2.825$, $p = .01$. Thus, univariate F-tests were conducted to determine single effects for spontaneous transfer and transfer propensity.

Univariate F-tests for spontaneous transfer indicated no statistically significant differences for the near transfer task, $F(1, 58) = .159$, $p = .692$, or the far transfer task, $F(1, 58) = 1.061$, $p = .307$. However, statistically significant differences for spontaneous transfer were found for the very far transfer task, $F(1, 58) = 5.150$, $p = .027$. That is, students with LD performed significantly better than students with LA on measures of spontaneous transfer for the very far transfer task, but were not significantly different on the near or far transfer tasks. Means and standard deviations for spontaneous transfer are listed in Table 5.

Insert Table 5

Univariate F-tests for transfer propensity indicated that no statistically significant differences were found for the near transfer task, $F(1, 58) = .462$, $p = .499$, or the very far transfer task, $F(1, 58) = .154$, $p = .696$. To the contrary, significant differences for transfer propensity were found for the far transfer task, $F(1, 58) = 5.828$, $p = .019$. That is, students with LD required significantly fewer prompts than students with LA to reach mastery for the far transfer task, but were not significantly different on the near and very far transfer tasks. Means and standard deviations for transfer propensity are listed in Table 6.

Insert Table 6

For the fourth session, Hotelling's t-test was used to simultaneously test for mean differences in maintenance unassisted and maintenance assisted for the three transfer tasks as well as the learning task. Statistically significant main effect differences were found, F (6, 53) = 2.825, p = .01.

Univariate F-tests were then conducted to determine single effects for maintenance unassisted and maintenance assisted for the three transfer tasks and learning task. No statistically significant differences were found for maintenance unassisted for the learning task (see previous section) or near transfer task, F (1, 58) = .159, p = 1.733. Statistically significant differences for maintenance unassisted were found, however, for the far transfer task, F(1, 58) = 9.728, p = .003, and the very far transfer task, F (1, 58) = 5.324, p = .025. That is, students with LD performed significantly better than students with LA on measures of maintenance unassisted for the far and very far transfer tasks. Means and standard deviations for maintenance unassisted are listed in Table 5.

For maintenance assisted, statistically significant differences were found for the far transfer task, F (1, 58) = 4.452, p = .039, and the very far transfer task, F (1, 58) = 8.198, p = .006. That is, students with LD needed significantly fewer prompts than students with LA to maintain their learning in the assisted condition for the far and very far transfer tasks. Lack of individual variance in scores on maintenance assisted for the learning and near transfer tasks negated conducting post hoc analyses. Means and standard deviations for maintenance assisted are listed in Table 6.

To determine differences for the two groups in performance trends on the transfer tasks over sessions three and four, two 2x3x2 multivariate analyses of variance with repeated measures were conducted. These analyses were conducted to determine whether significant mean differences in performance during the unassisted or assisted conditions existed for groups, transfer (i.e., near, far, and very far), and/or the repeated factors (i.e., sessions 3 and 4). For the first analysis (unassisted conditions), the dependent variables submitted to the analysis were spontaneous transfer and maintenance unassisted, both measured by number correct. A statistically significant main effect was found for group, $F(1, 58) = 6.81$, $p = .011$. A statistically significant main effect was also found for the repeated factors, $F(1, 58) = 44.01$, $p = .000$. Further, a statistically significant interaction effect was found for the repeated measures by group, $F(1, 58) = 5.56$, $p = .022$.

To interpret the source of this significant interaction effect, results from earlier univariate F-tests following Hotelling's t-tests conducted to analyze performance on the transfer tasks under unassisted conditions for the third (i.e., spontaneous transfer) and fourth sessions (i.e., maintenance) were used. These results indicated that the source of the interaction occurred for the far transfer task under the unassisted condition. That is, students with LD and students with LA performed similarly on the far transfer task in the third session. However, students with LD performed significantly better than students with LA on the far transfer task in the fourth session. See Figure 2 for a graph of the significant interaction.

Insert Figure 2

Statistically significant main effects were also found for transfer, $F(1, 57) = 91.267$, $p = .000$. No statistically significant interaction effects were found for transfer by the repeated measures, $F(2, 57) = 2.43$, $p = .097$, or transfer by the repeated measures by group, $F(2, 57) = .801$, $p = .454$. Note that the interaction between transfer and group approached significance, $F(1,57)=3.062$, $p=.055$. This finding can be explained the tendency of students with LD to outperform students with LA on the far and very far transfer tasks but not the near transfer task.

The second 2x3x2 multivariate analysis of variance with repeated measures across sessions 3 and 4 was conducted to determine whether significant mean differences in the assisted condition existed between group, transfer, and/or the repeated factors. The dependent variables were transfer propensity and maintenance assisted, both measured by the sum of the weighted prompts. A statistically significant main effect was found for group, $F(1, 58) = 7.48$, $p = .008$, the repeated measures, $F(1, 58) = 40.92$, $p = .000$, and for transfer, $F(2, 57) = 154.795$, $p = .000$.

Statistically significant interaction effects were found for group by transfer, $F(2, 57) = 3.642$, $p = .032$, and the repeated measures by transfer $F(2, 57) = 18.881$, $p = .000$. To the contrary, no statistically significant interaction effects were found for group by the repeated measures, $F(1, 58) = 3.642$, $p = .261$, or group by the repeated measures by transfer, $F(2, 57) = 1.466$, $p = .239$. See Figures 3 and 4 for graphs of the significant interactions.

Insert Figures 3 and 4

Post hoc t-tests were conducted to determine the source of the statistically significant group by transfer interaction and the repeated measures by transfer interaction. For the repeated measure by transfer interaction, statistically significant mean differences were found for the near transfer task, $t = 2.02$, $p = .048$, the far transfer task, $t = 2.64$, $p = .010$, and the very far transfer task, $t = 5.94$, $p = .000$. That is, when means were collapsed for the two groups, students performed significantly better in the fourth session than the third session.

For the group by transfer interaction, mean performance under the assisted condition for the near, far, and very far transfer tasks was collapsed across sessions 3 and 4 and compared for the two groups. Statistically significant mean differences were found for the far transfer task, $t = -2.53$, $p = .014$, and the very far transfer task, $t = -2.15$, $p = .035$. No statistically significant mean differences, however, were found for the near transfer task, $t = -.90$, $p = .373$.

Discussion

Interpreting the results of this study are challenging for two reasons. First, incongruencies exist between the results of this study and previous conclusions drawn regarding the ability of students with LD to transfer their learning. Second, the hypothesis of developmental delay in the problem-solving performance of students with LD is partially rejected. Findings of research based in Vygotskian theory, however, may provide some useful explanations.

Learning Task

In this study, students with LD were not significantly different from students with LA in performance on any measures of maintenance and learning. In similar research, however, ability level was a reliable indicator of performance on measures of learning speed and maintenance (Day & Hall, 1988; Ferrara, Brown, & Campione, 1986) but not initial rule knowledge (Campione, Brown, Ferrara, Jones,.& Steinberg, 1985; Day & Hall, 1988). Further, average-achieving students in the Day and Hall study out-performed students with LD in this study on measures of learning speed. This discrepancy, however, is supported in a study comparing students with LD and average-achieving students leading to Hall and Day's (1982) conclusion that students with LD are marked by a more reflective profile. That is, because of their disability, students with LD may learn more slowly but transfer more efficiently than students with lower ability, a hypothesis supported by the findings in this study.

Investigations of the problem-solving ability of students with LD provide additional explanation for the unexpected performance of these students on measures of learning speed. The need for more explicit instruction by students with LD in the present investigation may be the result of their difficulties in using feedback to modify strategies or generate hypotheses for problem-solving (see e.g., Stone & Michals, 1986).

Finally, nonsignificant differences and ceiling effects for maintenance unassisted may be explained by factors unique to this study. Contrary to previous research (e.g., Day & Hall, 1988), both groups had the opportunity to recalculate their work without being penalized. Thus, factors beyond the student's inability to maintain original rule knowledge (e.g., poor calculation skills or poor attention span) may have been responsible for lower maintenance unassisted scores in previous research.

Transfer Tasks

Unlike the learning task, students with LD outperformed students with LA on most measures of transfer and maintenance with the exception of near transfer. As with the learning task, the opportunity to recheck one's work for calculation errors may have been responsible for ceiling effects on tests of spontaneous transfer and maintenance unassisted for the near transfer task.

For the far and very far transfer task, performance differences for the two groups were inconsistent across measures of spontaneous transfer and transfer propensity. However, students with LD outperformed students with LA on all measures of maintenance for the two tasks. Similar research (e.g., Day & Hall, 1988) indicated that students with LD, because of higher ability levels, should have outperformed students with LA on all measures of transfer and maintenance. While trends in performance differences for the two groups support this finding, other explanations must be sought to interpret group differences on spontaneous transfer and transfer propensity in this study.

A simple phenomenon may be responsible for nonsignificant differences exhibited for spontaneous transfer on the far transfer task. On the test of spontaneous transfer, 13 students with LD reached mastery versus 9 students with LA. Prior to test completion, however, 4 additional students with LD were capable of determining the correct solution strategy. Thus, 17 students with LD as opposed to 9 students with LA required no prompting to reach mastery under the assisted conditions and significant differences in transfer propensity were found.

For the very far transfer task, two possible explanations exist for significant differences in spontaneous transfer and nonsignificant differences in transfer propensity. One, students with LD may have shown an intuitive understanding of the task but lacked the verbal ability (e.g., mean Verbal IQ = 95) to explain the exact strategy needed for solution. Second, students with LD tend to employ general heuristics as opposed to more specific strategies while problem solving (Swanson, 1989). Feasibly, students with LD in this study had enough intuitive knowledge of the task to apply a general problem-solving approach to correctly solve conflict problems without assistance. These same students, however, may have encountered difficulty in deriving the specific strategy needed to solve conflict problems.

Implications

In general, these results indicated that students with LD were more capable than students with LA of maintaining and transferring their learning. Thus, previous assumptions regarding the deficient transfer abilities of students with LD are called into question. Possibly, the ability to transfer learning is more closely related to general intelligence and is not the result of a specific learning disability. Replications of this study should be conducted which compare students with LD to nondisabled students matched on ability. These replications can be used to determine if differences in the learning and transfer profile can be attributed to differences in the characteristics of students with LD or are the result of variations in ability level between samples.

Results of this study also question the assumption of developmental delay in the problem-solving performance of students with LD. Students with LD outperformed students with LA on several measures of transfer and maintenance; therefore, challenging the assumption that students with LD exhibit delays in problem-solving performance similar to more immature learners. Possibly, previous studies which indicated developmental delays in the problem-solving performance of students with LD were confounded by failures to control for ability differences. Clearly, additional research which controls for ability in studying the problem-solving behavior of students with LD is needed.

In addition, dynamic assessments of problem-solving performance hold potential for improving professionals' conceptual understanding of students with LD. Nonsignificant performance differences on several measures of learning, maintenance, and transfer for the two groups indicate that students with LD do exhibit difficulties which result in performance similar to that of their lower ability peers. Research using dynamic assessment methods must include investigations of problem solving within the content areas. This research can be used to validate learning and transfer patterns in students with LD across tasks. Dynamic assessments of problem-solving performance may also contribute to explanations of heterogeneity in the LD population. Considerable variability in performance on the learning, maintenance, and transfer measures in this investigation indicate that subtypes of learning/transfer profiles may exist within the LD population.

A final implication of this study derives from the overall poorer performance of low-achieving students on measures of maintenance and transfer than students with LD. Because transfer and maintenance of knowledge are crucial skills in learning, the poorer performance of low-achieving students indicates that they may be at a greater disadvantage in school than students with LD. Questions arise regarding who is more disabled in academic settings, students with LD or low-achieving students, and who is more in need of specialized services to ensure learning and successful educational outcomes.

References

Adelman, H. S. & Taylor, L. (1986). The problems of definition and differentiation and the need for a classification schema. Journal of Learning Disabilities, 19, 515-520.

Alley, G. R., Deshler, D. D., Clark, F. L., Schumaker, J. B., & Warner, M. M. (1983). Learning disabilities in adolescent and adult populations: Research implications (Part II). Focus on Exceptional Children, 15, 1-14.

Bakeman, R. & Gottman, J. M. (1986). Observing interaction: An introduction to sequential analysis. Cambridge: Cambridge University Press.

Brown, A. L., Bransford, J. D., Ferrara, R. A., & Campione, J. C. (1982). Learning, remembering, and understanding. In J.H. Flavell & E.M. Markman (Eds.), Handbook of child psychology (4th ed.): Cognitive development (Vol. 3). New York: Plenum.

Brown, A. L. & Campione, J. C. (1986). Inducing flexible thinking: A problem of access. In M. Friedman, J.P. Das, & N. O'Connor (Eds.), Intelligence and learning. New York: Plenum.

Butterfield, E. C. & Ferretti, R. P. (1987). Toward a theoretical integration of cognitive hypotheses about intellectual differences among children. In J. G. Borkowski & J. D. Day (Eds.), Cognition in special children: Comparative approaches to retardation, learning disabilities, and giftedness (pp. 195-232). Norwood, NJ: Albex.

Campione, J. C., Brown, A. L., Ferrara, R. A., Jones, R. S., & Steinberg, E. (1985). Breakdowns in flexible use of information: Intelligence-related differences in transfer following equivalent performance. Intelligence, 9, 297- 315.

Day, J. D. & Hall, L. K. (1988). Intelligence-related differences in learning and transfer and enhancement of transfer among mentally retarded persons. American Journal on Mental Retardation, 93, 125-137.

Ferrara, R. A., Brown, A. L., & Campione, J. C. (1986). Children's learning and transfer of inductive reasoning rules: Studies of proximal development. Child Development, 57, 1087-1099.

Hall, L. K. & Day, J. D. (1982). A comparison of the zone of proximal development in learning disabled, mentally retarded, and normal children. Paper presented at the meeting of the American Educational Research Association, New York.

Hammill, D. D. (1990). On defining learning disabilities: An emerging consensus. Journal of Learning Disabilities, 23, 74-84.

Keogh, B. K. (1988). Learning disability: Diversity in search of order. In M. C. Wang, M. C. Reynolds, & H. J. Walberg (Eds.), Handbook of special education: Research and practice for mildly handicapped conditions (Vol. 2, pp. 225-252). New York: Pergamon.

Kolligan, J. Jr. & Sternberg, R. J. (1987). Intelligence, information processing and specific learning disabilities: A triarchic synthesis. Journal of Learning Disabilities, 20, 8-17.

Lindquist , E. F. & Hieronymus, M. N. (1976). Iowa Test of Basic Skills. Boston: Houghton Mifflin Company.

Meltzer, L. J., Solomon, B., Fenton, T., & Levine, M. D. (1989). A developmental study of problem-solving strategies in children with and without learning difficulties. Journal of Applied Developmental Psychology, 10, 171-193.

Reynolds, C. R. (1984-1985). Critical measurement issues in learning disabilities. The Journal of Special Education, 18, 451-476.

Sattler, J. M. (1982). Assessment of children's intelligence and special abilities (2nd ed.). Boston: Allyn and Bacon.

Science Research Associates Committee on the SRA test. (1987). SRA test of Basic Skills. Chicago: Science Research Associates.

Siegler, R. S. (1976). Three aspects of cognitive development. Cognitive Psychology, 8, 481-520.

Stanovich, K. E. (1986). Cognitive processes and the reading problems of learning disabled children: Evaluating the assumption of specificity. In J. Torgeson & B. Wong (Eds.), Psychological and educational perspectives on learning disabilities (pp. 87-131). New York: Academic Press.

Stone, A. & Forman, E. A. (1988). Differential patterns of approach to a complex problem-solving task among learning disabled adolescents. Journal of Special Education, 22, 167-185.

Stone, A. & Michals, D. (1986). Problem-solving skills in learning-disabled children. In S. J. Ceci (Ed.), Handbook of cognitive, social, and neuropsychological aspects of learning disabilities (Vol. 1). Hillsdale, N. J.: Erlbaum.

Swanson, H. L. (1987). Information processing theory and learning disabilities. An overview. Journal of Learning Disabilities, 20, 3-7.

Swanson, H. L. (1988). Toward a metatheory of learning disabilities. Journal of Learning Disabilities, 21, 196-209.

Swanson, H. L. (1989). Strategy instruction: Overview of principles and procedures for effective use. Learning Disability Quarterly, 12, 3-14.

Telzrow, C.F. & Speer, B. (1986). Learning-disabled children: General suggestions for maximizing instruction. Techniques, 2, 341-352.

Vygotsky, L. S. (1978). Mind in society: The development of higher psychological process. Cambridge, MA: Harvard University Press.

Wechsler, D. (1974). Wecshler intelligence scales for children-Revised. New York: Psychological Corp.

Woodcock, R. W. & Johnson, M. B. (1977). Woodcock-Johnson psycho-educational battery. Allen, TX: DLM Teaching Resources.

Ysseldyke, J. E., Thurlow, M., Graden, J., Wesson, C., Algozzine, B., & Deno, S. (1983). Similarities between low achievers and students classified learning disabled. Exceptional Education Quarterly, 4, 75-91.

Table 1

Demographics for Students with Learning Disabilities.

Site 1:

						WISC-R			WJ II		IOWA	
#	Sex	Age	Grd	SES	Race	V	P	F	Rdg	Math	Rdg	Math
1	M	12.11	7	1	1	100	121	110	88	92	20	14
2	M	14.5	8	0	1	77	105	89	75	75	9	4
3	M	13.4	7	3	1	101	124	112	80	78	8	16
4	M	13.4	8	0	1	105	111	108	115	84	27	6
5	F	13.2	7	3	4	84	120	100	84	68	26	29
6	M	13.4	7	3	5	85	112	97	82	82	8	2
7	M	12.4	7	0	1	-	-	114	86	117	34	40
8	M	13.7	7	0	1	95	109	101	74	82	6	1
9	M	13.6	8	0	1	106	112	109	82	91	4	3
10	M	13.0	7	1	1	84	105	92	75	84	2	16
11	M	14.1	8	3	1	105	129	118	90	97	48	33
12	M	12.11	7	1	3	97	120	108	81	80	61	5
13	M	13.3	7	0	3	87	108	96	83	82	6	12
14	M	13.11	8	0	1	97	123	109	75	108	24	58
15	M	13.5	8	1	1	90	115	101	87	81	11	16
16	M	12.6	7	1	4	92	112	101	73	89	14	10
17	M	13.11	7	1	1	105	129	116	90	97	22	8
18	M	11.11	7	0	1	113	124	121	96	105	26	16
19	F	12.3	7	1	1	91	114	101	80	102	28	10
Means		13.3				95	116	106	84	89	23	15
Std. dev.						9.7	7.7	9.0	10.0	12.5	15.5	14.8

Site 2:

						WISC-R			WJ II		SRA	
#	Sex	Age	Grd	SES	Race	V	P	F	Rdg	Math	Rdg	Math
20	M	14.7	8	0	1	118	122	122	87	110	31	41
21	M	14.1	8	0	1	125	128	128	102	107	31	13
22	M	13.6	7	0	1	88	115	102	89	87	31	13
23	F	13.2	7	0	1	94	121	106	81	95	12	51
24	F	14.3	7	0	1	91	114	101	82	91	24	37
25	M	13.7	7	0	1	123	110	114	118	75	28	41
26	M	13.2	7	3	5	107	109	109	98	77	13	6
27	M	12.3	7	0	1	98	117	107	98	77	5	1
28	M	14.1	8	1	1	95	118	105	95	88	50	11
29	F	14.5	8	0	1	95	111	102	83	91	40	38
30	F	13.8	7	3	1	84	114	97	80	79	13	6
Means		13.3				102	116	108	91	90	31	26
Std. dev.						14.4	6.7	9.4	11.5	11.2	24.6	18.4

Notes. [a]Race: 1=Caucasian, 2=Asian, 3=Black, 4=Hispanic, 5=American Indian.

[b]SES: 0=nonsubsidized lunch, 1=full subsidized lunch, 3=partially subsidized lunch.

[c]WISC-R and WJ scores are in standard score units (M=100, SD=15) and ITBS and SRA scores are based on national percentile ranks.

Table 2

Demographics for Students with Low Achievement

Site 1:

#	Sex	Age	Grade	SES	Race	IOWA Rdg	Math	V	Q	NV
1	M	12.8	7	0	3	17	2	35	6	17
2	F	14.3	7	1	5	32	8	7	6	6
3	F	13.5	8	0	1	24	6	29	11	33
4	F	13.5	7	1	1	14	16	6	13	7
5	F	14.5	8	1	3	27	5	16	17	21
6	M	13.9	7	3	1	2	5	4	6	17
7	M	13.0	7	3	3	22	7	6	8	3
8	M	14.2	7	1	1	20	14	40	29	8
9	M	13.7	8	1	3	18	7	16	8	9
10	F	13.8	8	1	4	15	12	13	33	40
11	F	13.6	7	3	1	26	29	3	3	11
12	F	13.2	7	3	1	14	24	17	16	5
13	F	14.7	8	1	4	6	12	8	11	25
14	F	13.10	7	3	1	28	37	33	21	40
15	M	13.3	8	1	3	27	6	11	17	16
16	F	12.8	7	0	3	10	5	9	5	8
17	M	13.3	7	1	1	32	34	35	13	23
18	M	13.3	7	1	3	26	10	13	19	25
19	F	14.1	7	1	3	24	45	45	38	35
Means		13.7				20	15	18	15	18
Std. dev.						8.5	12.6	13.5	9.8	12.0

Site 2:

#	Sex	Age	Grade	SES	Race	SRA Read	Math	Educ. Ab.
20	F	13.0	7	0	5	27	31	4
21	M	13.4	7	0	1	11	3	3
22	M	13.4	7	0	1	31	1	12
23	F	12.5	7	0	1	43	32	35
24	M	12.11	7	0	1	58	33	12
25	F	13.11	7	3	4	2	1	8
26	F	14.6	8	1	4	24	11	8
27	F	14.5	8	0	1	33	34	7
28	F	13.5	7	0	1	20	27	16
29	M	13.11	8	0	1	31	31	26
30	M	14.10	7	0	1	6	11	7
Means		13.8				26	20	13
Std. dev.						16.3	14.0	9.9

Notes. [a]Race: 1=Caucasian, 2=Asian, 3=Black, 4=Hispanic, 5=American Indian.

[b]SES: 0=nonsubsidized lunch, 1=full subsidized lunch, 3=partially subsidized lunch.

[c]ITBS and SRA scores are based on national percentile ranks.

Figure Caption

Figure 1. Overview of the procedures and analyses used in this study. (Design used: A 2(Group: LD, LA) by 4(Session: Pretest, Training, Maintenance/Transfer, Delayed Maintenance) factorial repeated-measures design.

Session	Research Questions	Conceptual DV	Operational DV	Analysis
1 Pretest	1. Will students with LD perform differently than students with LA on initial levels of rule knowledge?	Initial level of rule knowledge	Number correct	ANOVA
2 Training	2 Will students with LD perform differently than students with LA on measures of learning speed?	Learning speed	Sum of the weighted prompts	ANOVA
3 Maintenance/transfer	3 Will students with LD perform differently than students with LA on measures of maintenance in the unassisted and assisted conditions for the learning task in session 3?	Maintenance unassisted	Number correct	Hotelling's t-test
		Maintenance assisted	Sum of the weighted prompts	
4 Delayed maintenance	4 Will students with LD perform differently than students with LA on measures of maintenance in the unassisted and assisted conditions for the learning task in session 4?	Maintenance unassisted	Number correct	Hotelling's t-test
		Maintenance assisted	Sum of the weighted prompts	
3 Maintenance/transfer	5 Will students with LD perform differently than students with LA on measures of spontaneous transfer for near, far, and very far transfer tasks?	Spontaneous transfer	Number correct	Hotelling's t-test
3 Maintenance/transfer	6 Will students with LD perform differently than students with LA on measures of transfer propensity for near, far, and very far transfer tasks?	Transfer propensity	Sum of the weighted prompts	
4 Delayed maintenance	7 Will students with LD perform differently than students with LA on measures of maintenance for the three transfer tasks under the assisted and unassisted conditions?	Maintenance unassisted	Number correct	Hotelling's t-test
		Maintenance assisted	Sum of the weighted prompts	
3 Maintenance/transfer 4 Delayed maintenance	8 Will students with LD show different performance trends under both the assisted and unassisted conditions than students with LA on near, far, and very far transfer measures?	Spontaneous transfer Maintenance unassisted	Number correct	MANOVA with repeated measures
		Transfer propensity Maintenance assisted	Sum of the weighted prompts	MANOVA with repeated measures

Table 3

Mean Number Correct (Unassisted Condition) for Four-Peg Balance Scale

		Pretests		Immediate Maintenance/Transfer		Delayed Maintenance	
Group	N	Mean	SD	Mean	SD	Mean	SD
LD	30	15.83	2.90	14.03	2.27	14.60	1.30
LA	30	14.73	2.65	13.70	2.67	14.97	0.18

Note. Mean number correct is a measure of initial level of rule knowledge and maintenance unassisted.

Table 4

Mean Sum of the Weighted Prompts (Assisted Condition) for the Four-Peg Balance Scale

		Training		Immediate Maintenance/Transfer		Delayed Maintenance	
Group	N	Mean	SD	Mean	SD	Mean	SD
LD	30	23.42	14.85	0.96	3.38	0.00	0.00
LA	30	26.25	11.95	1.56	4.25	0.00	0.00

Note. Mean sum of the weighted prompts is a measure of learning speed and maintenance assisted.

Table 5

Mean Number Correct (Unassisted Condition) for Transfer Tasks in Third and Fourth Sessions

		Near Transfer		Far Transfer		Very Far Transfer	
Group	N	Mean	SD	Mean	SD	Mean	SD
LD[a]	30	9.10	1.84	6.83	2.90	6.43	5.53
LA[a]	30	9.30	2.04	6.30	2.51	1.63	1.43
LD[b]	30	9.97	0.18	8.93	2.08	7.53	2.01
LA[b]	30	9.57	1.65	6.93	2.83	6.37	1.90

Notes. [a]Mean number correct is a measure of spontaneous transfer.

[b]Mean number correct is a measure of maintenance unassisted.

Table 6

Mean Sum of Weighted Prompts (Assisted Condition) for Transfer Tasks Third and Fourth Sessions

		Near Transfer		Far Transfer		Very Far Transfer	
Group	N	Mean	SD	Mean	SD	Mean	S
LD[a]	30	0.46	1.79	9.06	12.74	37.74	22.09
LA[a]	30	0.85	2.59	17.18	13.32	39.68	15.67
LD[b]	30	0.00	0.00	5.96	11.77	13.62	14.26
LA[b]	30	0.28	1.55	12.63	12.67	25 46	17.61

Notes. [a]Mean sum of the weighted prompts is a measure of transfer propensity.

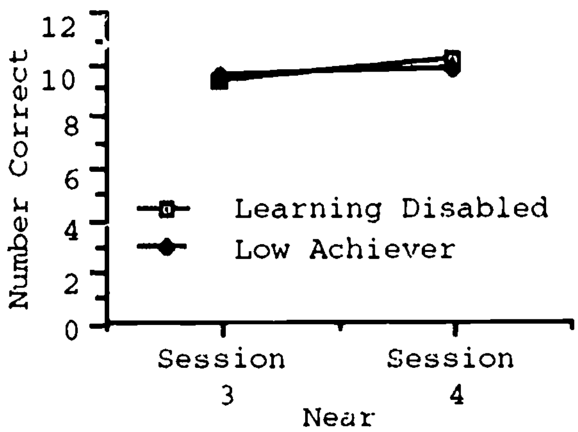
[b]Mean sum of the weighted prompts is a measure of maintenance assisted.

Figure Caption

Figure 2. Mean performance for group by the repeated measures on near transfer/unassisted conditions. (Number correct is the dependent measure.)

Figure 3. Mean performance for group by the repeated measures on far transfer/unassisted conditions. (Number correct is the dependent measure.)

Figure 4. Mean performance for group by the repeated measures on very far transfer/unassisted conditions. (Number correct is the dependent measure.)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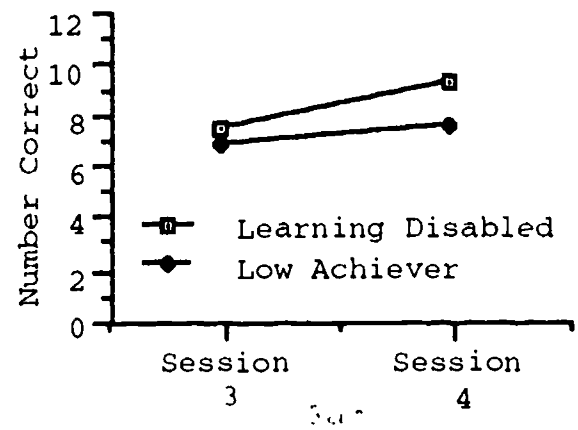
10
8
6
4
2
0
Number Correct
Learning Disabled
Low Achiever
Session 3
Session 4
Near


12
10
8
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4
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0
Number Correct
Learning Disabled
Low Achiever
Session 3
Session 4

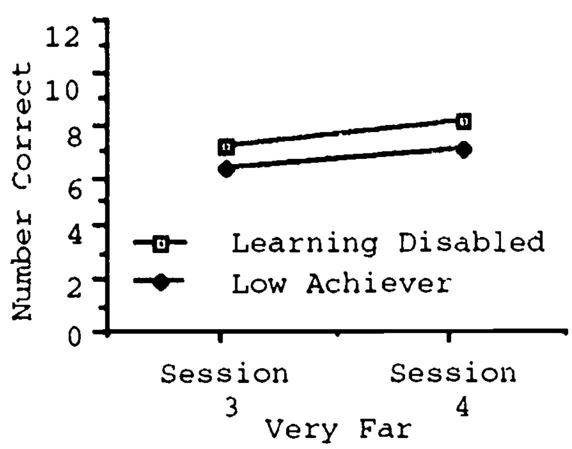
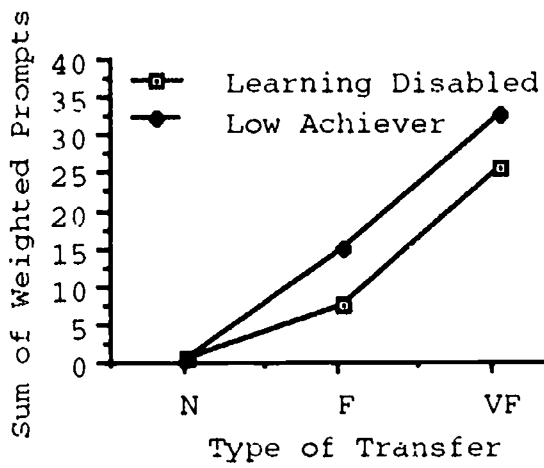
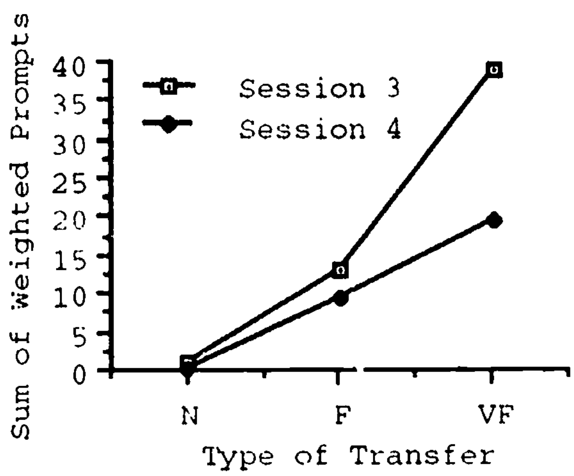

12
10
8
6
4
2
0
Number Correct
Learning Disabled
Low Achiever
Session 3
Session 4
Very Far

Figure Caption

Figure 5. Mean performance on near, far and very far transfer collapsed for sessions/assisted conditions (group by transfer). (Sum of the weighted prompts is the dependent measure.)

Figure 6. Mean performance on near, far and very far transfer collapsed for groups/ assisted conditions (transfer by the repeated measures). (Sum of the weighted prompts is the dependent measure.)


Sum of Weighted Prompts
40
35
30
25
20
15
10
5
0
Learning Disabled
Low Achiever
N
F
VF
Type of Transfer


Sum of Weighted Prompts
40
35
30
25
20
15
10
5
0
Session 3
Session 4
N
F
VF
Type of Transfer